M/027/006

GRAYMONT

Date: **February 18, 2003**

To: **Doug Jensen**
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CC: **Mike B., Herb H., Joe B., Marc M., Terry M.**

From: **Robert Robison** RR

RE: **Cricket Mountain Plant Vegetation Assessment Report, 2002**

Doug,

As per our telephone conversation last week, enclosed please find a copy of the vegetation assessment report for Cricket Mountain for 2002. Please contact me if you have questions or require additional information.

Thank you,

Bob

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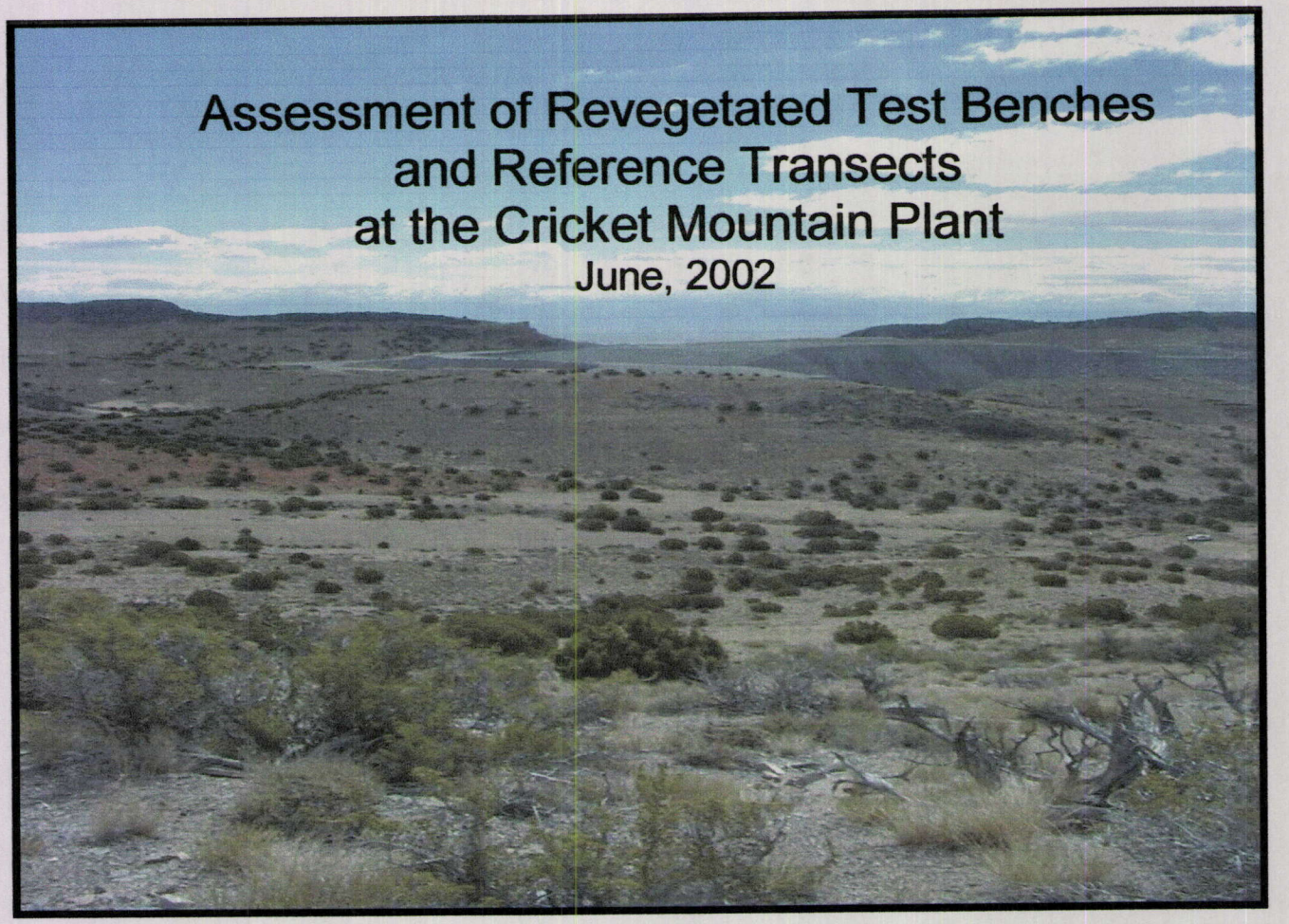
Reviewed 3/5/03 MAB

Assessment of Revegetated Test Benches and Reference Transects at the Cricket Mountain Plant

June, 2002



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SCOPE

The scope of this work was to assess the revegetation efforts at Graymont Western U.S. Inc (Graymont) Cricket Mountain Plant and to evaluate the reference areas for the 2002 growing season.

INTRODUCTION

The Cricket Mountain Plant, owned and operated by Graymont, Inc, is an active limestone quarry south of Delta, Utah. Graymont has reclaimed and revegetated old quarry benches that are no longer in active operation. Since revegetation has proven excessively difficult on these areas of the quarry, Graymont initiated a program to evaluate a variety of revegetation methods in 1996. In April and December of 1996, several benches were treated and seeded with various soil, fertilization and mulching practices. In the fall of 1998, many new revegetation methods were instated. The different revegetation methods untilized in 1998 were a result of a cooperative effort form representatives from Graymont, the Natural Resource Conservation Service (NRCS), and the Utah State Division of Oil, Gas, and Mining (DOGM). These "test" benches will assist Graymont in determining reclamation success of seed mixes, growth amendments, seed bed preparation techniques, and experimental surficial amendments.

The treatments applied to benches in November 1998 and 1996 are shown in Table 1 (Appendix A). Seed mixes used in 1998 and 1996 are outlined in Table 2a and 2b (Appendix A).

In addition to the assessment of the revegetation methods, Graymont annually evaluates reference transects (undisturbed areas) in native vegetation areas near the Cricket Mountain Plant for comparison purposes for growing conditions and variation in vegetation cover.

METHODS

Data on vegetation cover and species richness (diversity) were collected on June 13 and 14, 2002. Vegetation on each bench and in the reference areas was sampled using a point transect method via an optical point projection device. Cover was recorded every two meters on a 100 meter transect. A total of 100 points were sampled for each bench, and data were recorded at each point (plant species, rock, litter, bare ground or gravel). Three parallel transects were sampled in the same manner at each of the two reference areas, for a total of 300 points for each transect. Presence of species on the benches and in the reference areas not captured by the optical projection device were also recorded and documented as <1 to represent <1 % cover in the area. Nomenclature follows Welsh et al., A Utah Flora (1993).

RESULTS

BENCHES

Table 3 in Appendix A is a tabular summary of detailed information (vegetation cover, relative cover, and species present) regarding each bench sampled. 2002 was an extremely dry year as the precipitation for the area was much below normal levels. Even though it was an excessively dry year, the vegetation on the benches seemed to be relatively healthy. There were signs of early seed set and senescence, although this is a logical sign for such dry conditions.

EAST BENCHES (SEEDED IN DECEMBER 1996)

5940E –Total vegetation cover was approximately 3% along the 100m transect. All of the vegetation hit with the scope was intermediate wheatgrass (*Elytrigia intermedia ssp trichoporum*). Other species that were not intercepted by the transect line included crested wheatgrass (*Agropyron cristatum*), Russian wildrye (*Psathrostachys juncea*), purple three-awn (*Aristida pupurea*), Cheatgrass (*Bromus tectorum*), forage kochia (*Kochia prostrata*), shadscale (*Atriplex confertifolia*), bluebunch wheatgrass (*Agropyron spicatum*), Indian ricegrass (*Oryzopsis hymenoides*), halogeton (*Halogeton glomeratus*), black sagebrush (*Artemisia nova*), broom snakeweed (*Gutierrezia sarothrae*) and four wing saltbush (*Atriplex canescens*). (See Appendix B)

5900E - Total vegetation cover was approximately 1% along the 100m transect. The scope intercepted a four-wing saltbush shrub. The high walls above this bench are beginning to fall, leaving large piles of loose boulders on the bench. The vegetation present on this bench not intercepted by the transect was intermediate wheatgrass, Indian ricegrass, Russian wildrye, black sage, halogeton, shadscale, and forage kochia. (See Appendix B)

WEST BENCHES-

5960W – Vegetation cover was <1% along the 100m transect on this bench. Except for the few shadscale and four-wing saltbush on the South end of this bench, 5960W was very sparsely vegetated. Other species found on this bench were crested wheatgrass and Russian wildrye. (See photos in Appendix B).

5940W – Vegetation cover was 4% along the 100m transect. Four wing saltbush accounted for 75% of the cover, while shadscale accounted for the other 25%. The bench is very sparsely vegetated except for a number of shadscale and four-wing saltbush on the south end. Other species encountered on this bench were halogeton, intermediate and crested wheatgrasses, and Russian wildrye. See Appendix B for photo.

5920W – Vegetation cover was 16% along the 100m transect. Crested wheatgrass and Siberian wheatgrass (*Agropyron fragile*) were the most prevalent species, each with a relative cover of 31%. Streambank wheatgrass (*Agropyron riparium*) accounted for 19% of the relative cover, Eaton's penstemon (Penstemon eatonii) accounted for 13% of the cover and thickspike wheatgrass (Elymus lanceolatus ssp lanceolatus) accounted for 6% of the vegetation cover. Other species found on this bench were shadscale, four-wing

saltbush, Russian wildrye, Munroe globemallow (*Sphaeralcea munroana*), intermediate wheatgrass, cheatgrass, yellow sweetclover, black sage, Indian ricegrass, and forage kochia (See photos in Appendix B).

5900W –Vegetation cover was 9% along the 100m transect for this bench. Crested wheatgrass accounted for 33% of the vegetation cover, while Siberian wheatgrass and Indian ricegrass each accounted for 22% of the vegetation cover. Other dominant species on the bench were four-wing saltbush and Eaton's penstemon (11% relative cover each). Other species present on this bench were intermediate wheatgrass, cheatgrass, streambank and thickspike wheatgrasses, Munroe's globemallow, and forage kochia (See photos in Appendix B).

5880 W – Cover on this bench was 21% along the 100m transect, with an abundance of species. Crested wheatgrass was the most abundant species, accounting for 71% of the cover, while Siberian wheatgrass accounted for 24%. Streambank wheatgrass was 5% of the vegetation cover. Other species present on this bench included four-wing saltbush, Indian ricegrass, thickspike wheatgrass, black sagebrush, Monroe's globemallow, Eaton's penstemon, forage kochia, Palmer's penstemon (*Penstemon palmeri*), and blue mustard (*Chorispora tenella*). (See photo in Appendix B).

5880 middle – This bench had a cover value of 16% along the 100m transect. Crested wheatgrass accounted for 62% of the vegetation cover, while Siberian wheatgrass accounted for 19% of the vegetation cover. Streambank wheatgrass accounted for 13% of the vegetation cover, and bottlebrush squirreltail accounted for the other 7% of the vegetation cover. Other species encountered on this bench were thickspike wheatgrass, Indian ricegrass, Eaton's penstemon, Monroe's globemallow, black sagebrush, four-wing saltbush, shadscale, yellow sweetclover, Palmer's penstemon, forage kochia, and broom snakeweed (*Gutierrezia sarothrae*) (See Appendix B).

5880 North – This area of the 5880 bench was further north than 5880 Middle, and had smaller fines as part of the growth medium instead of larger cobbles as in 5880 middle. Total vegetation cover was 8% along the 100m transect. The majority of the cover was four-wing saltbush at 50%. Crested wheatgrass accounted for 25%, and the other 25% of the vegetation cover was evenly split between Gardner's saltbush (*Atriplex gardneri*) and halogeton. Other species not intercepted by the transect were cheatgrass, Indian ricegrass, forage kochia, Munroe's globemallow, Eaton's penstemon, shadscale, and black sagebrush (See Appendix B).

5900 – Previous years data concentrated on the only the area of the bench covered by limestone fines. This year, to capture a better estimate of the entire 5900 bench, the transect was laid in approximately equal parts of limestone fines and limestone cobbles. The area covered with limestone cobbles has higher vegetation cover. This bench had a cover value of 10% along the 100m transect. The majority of the cover was provided by Siberian wheatgrass (60% relative cover), while yellow sweetclover and four-wing saltbush accounted for 10% relative cover each, and halogeton accounted for the other 20% of the vegetation cover. Other species encountered on this bench were black sagebrush, crested wheatgrass, cheatgrass, Gardner's saltbush, Eaton's Penstemon, forage kochia, and shadscale (See photos in Appendix B).

5940NW – Vegetation cover was 18% along the 100m transect on this bench. 5940NW was the only bench treated in 1996 that included a topsoil amendment. Most of the cover on the transect was accounted for by intermediate wheatgrass (44% relative cover), followed by Russian wildrye (22% relative cover), and cheatgrass (17% relative cover). Other species with significant cover were yellow sweetclover, forage kochia and four-wing saltbush (each with 5.5% relative cover). Other species present on this bench, but not intercepted by the transect were shadscale, halogeton, crested wheatgrass and bottlebrush squirreltail (*Elymus elymoides*) (See Appendix B).

5920NW- This bench had a cover of 10% along the 100m transect. Four-wing saltbush accounted for 50% of the vegetation cover on this bench. Crested wheatgrass had a relative cover of 20%, while Siberian wheatgrass accounted for 30% of the cover. Other species encountered on this bench were cheatgrass, streambank wheatgrass, Eaton's penstemon, forage kochia, halogeton, black sagebrush, Gardner's saltbush and shadscale. (See Appendix B)

REFERENCE TRANSECTS

The reference transects are located approximately ¾ mile West of the Poison Mountain Quarry. The location of the reference transects was chosen in 1998 for similar plant species, vegetation densities, exposed limestone, slope and aspect. (See Appendix C for photos and locations of Transects 1 and 2)

Transect 1 (VT-98-1) – Total vegetation cover for this transect was 23.3% +/-3.5%. Cool season perennial grasses comprised almost 43% of the vegetation cover. Bluebunch wheatgrass (*Agropyron spicatum*) was the most abundant cool season grass (37.2% relative cover), while Indian ricegrass (*Oryzopsis hymenoides*) contributed 5.7% of the total vegetation cover. Needle-and-thread (*Stipa comata*) and Sandberg's bluegrass (Poa sandbergii) were present on the transect, but were not captured by the scope. Warm season grasses such as purple threeawn (*Aristida purpurea*) and galleta grass (*Hilaria jamesii*) and perennial forbs such as Munroe's globemallow and stemless goldenweed (*Haplopappus acaulis*) were present on the transect, but were not intercepted by the scope. Gray's lomatium (Lomatium grayii) was the only perennial forb that was intercepted by the scope and comprised 1.4% of the total vegetation cover. Sub-shrubs (plants that are woody at the base, but die back to the ground surface every year) such as broom snakeweed and rock spirea (*Petrophytum caespitosum*) provided almost 13% of the total cover. Most of sub-shrub cover was supplied by broom snakeweed. Shrubs contributed about 31% of the total vegetation cover. Most abundant was black sagebrush, (17.2% relative cover), while cliffrose (*Purshia mexicana*) was almost 13% of the total vegetation cover. Goldenbush (Haplopappus watsonii) was only 1.4% of the total vegetation cover. Juniper trees (*Juniperus osteosperma*) contributed about 11% to the total vegetation cover.

Species represented with a <1 in Appendix C -Table 1 denotes the presence of the species on the transect, but not observed with the optical scope.

Ground cover was dominated by gravel at 34% of the total cover, followed by rock (24.6%), litter (12.7%), and bare ground (5.0%). Gravel was defined as rock fragments less than 2 inches in diameter.

Transect 2 (VT-98-2) – Total vegetation cover for reference transect 2 was 26.3% +/- 2.1%. Almost half of the vegetation cover was generated by bluebunch wheatgrass (49.3% relative cover). Warm season grasses (namely purple threeawn) contributed 5% of the total vegetation cover. Sub-shrubs- broom snakeweed and rock spirea (*Petrophytum caespitosum*)- contributed 11.3% of the total vegetation cover. Shrubs contributed 25% of the total vegetation cover. The shrub cover was almost equally divided between black sagebrush and cliffrose (11.4% and 12.6% relative cover consecutively). Utah juniper accounted for 8.3% of the total vegetation cover. Species denoted with a <1 in appendix C - Table 2 signify that the species was present on the transect, but was not observed by the optical projection device.

Total ground cover was dominated by rock (33.3%), followed by gravel (22%), and litter (8.67%). Total ground cover was 90.3%, which means bare soil accounted for the other 9.67% of the ground cover.

DISCUSSION

In order to meet bond release requirements for reclamation, vegetation cover must reach 70% of the natural vegetation cover and must be able to serve the proposed post-mining land-use function (e.g. wildlife habitat, grazing use, etc). The average vegetation cover value for the natural areas was 24.8% with a standard deviation of 3%. Therefore, revegetated benches must reach a cover value of approximately 17.4% with similar species and life-form composition when compared to the reference area. Cover values on the benches assessed ranged from <1% cover to 18% cover, with most of the cover being accounted for by introduced and native grasses. As the vegetation becomes more established, and shrub and forb species contribute more to the overall vegetation cover, bond release becomes more likely. As this time approaches, it may be helpful to place three transects on each bench to get a more statistically defensible sample of the vegetation on each bench. It may benefit Graymont Lime to request bond release for those benches nearing the standard for vegetation cover and post-mining land use. This way, Graymont can concentrate efforts on reclamation efforts on those benches that clearly do not meet bond release standards. Benches that may be ready for bond release in the near future are 5940NW, 5920W, and 5880W.

BENCHES SEEDED IN 1996

Table 1 below shows the comparison of benches that were seeded in 1996. Many of these benches continue to be sparsely covered with vegetation and will likely remain in this state unless action is taken. Benches 5960W and 5940W are particularly barren, most likely due to the combination of the low seeding rate, low mulching rate and lack of growth media. Benches 5940E and 5900E have a bit more vegetation cover on them, likely due to higher seeding and mulching rates. However, the vegetation cover on the East benches is clustered in areas where residual mulch lies or in areas better protected from the elements. Bench 5940E is slowly being colonized by native species on the south end. The proximity to native seed sources is a benefit for potentially successful revegetation. If nothing further is done to this bench, it may take a number of decades to reach the level of vegetation cover similar to that of the native area surrounding it, depending on weather patterns.

Bench 5940NW was seeded in 1996 with the addition of topsoil. The addition of this growth media is most likely responsible for the high vegetation cover on this bench. Each year, 5940NW

continues to grow and propagate, providing sufficient vegetation cover to meet present bond release criteria. Bench 5940NW carries the most weight in terms of swaying the annual average of vegetation cover for these benches.

Table 1. Changes in cover values on revegetated benches in 1998, 1999, 2000, 2001 and 2002.

	1998	1999	2000	2001	2002
5940E	3%	5%	4%	7%	3%
5900E	4%	1%	<1%	5%	1%
5940W	1%	1%	2%	2%	4%
5960W	<1%	<1%	<1%	<1%	<1%
5940NW	13%	23%	19%	25%	18%
Average	**4.2%**	**6.0%**	**5.0%**	**7.8%**	**5.2%**

BENCHES SEEDED IN NOVEMBER 1998

Many of the benches sampled and documented in 1998 were re-treated in the fall of that year. Several seedbed mixtures and preparation techniques were utilized to determine which methods would ultimately be the most successful. Generally, the benches left with a smooth surface (which also corresponds with less added topsoil) generally lacked the vegetation cover of the benches left with rough surface topography. Benches 5880N, 5900 and 5920 NW had vegetation covers of 8%, 10% and 10% respectively. However, each of these benches did display an impressive number of species present for the relatively low cover.

Evaluation of bench treatments

A combination of select soil amendments, limestone cobbles as a substrate augmentation material, and the practice of leaving an uneven surface has been the most likely permutation for successful reclamation. However, several treatments may be appropriate for better site preparation prior to seeding. Different costs are associated with each alternative. By evaluating the following projected success designations and comparing treatment costs, an acceptable cost/success ratio is obtainable.

Substrate Augmentation (mix)	Success Potential
▪ No surface application	low
▪ Limestone fines only	low
▪ Limestone fines with select material	medium
▪ Select material only	high
▪ Limestone fines with cobble	low-medium
▪ Limestone fines w/select material + cobble	high
▪ Cobble with select material	high
▪ Limestone fines w/compost	medium
▪ Limestone fines w/compost and cobble	medium-high

Surface or Mulch Application (est. 4-6 inch)	Success Potential
▪ No mulch application	low
▪ Select material	high
▪ Compost	high
▪ Straw	medium
▪ Fiber Blanket	medium

Substrate Surface Preparation	Success Potential
▪ Smooth bed	low
▪ Rough - dump substrate	low-medium
▪ Rough - dump and rip substrate	medium

Of the various scenarios with consideration to cost, it is recommended to use a limestone fine/cobble mix in a 1:1 ratio, with 6" select substrate (if available) and/or compost (organic amendment) surface application, and leaving a rough surface. Consideration should be given to using an approved mulch material secured either by crimping (not via dozer tracking) or with an organic tackifier. If mulch is added, the use of Bio-Sol (or any other organic slow-release fertilizer) at approximately 1000-1500 lbs/acre is recommended to boost the nutrient availability in the growth medium.

Seed mixes for revegetation of benches in the future should definitely include two to four pounds per acre of bluebunch wheatgrass (*Pseudoroegneria spicata ssp. spicata* var. Secar). This grass is the dominant grass in the area and should do well for reclamation of the benches.

REFERENCE TRANSECTS

Comparison of 1998, 1999, 2000, 2001 and 2002 data – Appendix C - Table 3 shows the values of the reference transects for the years 1998, 1999, 2000, 2001 and 2002. Since the range of natural variation is so broad in native vegetation communities, no significant differences can be declared. However, trends can be noted. The difference in the vegetation cover attributable to Utah Juniper and many shrubs in these years is likely due to a slight difference in transect placement. Transect location can change these numbers considerably since the trees are sparsely spaced throughout the community. Additionally, slight changes in the timing and amount of precipitation can make considerable changes in growth stages and annual plant production from year to year.

SUMMARY

An assessment of various revegetation techniques was performed at Graymont Lime's Cricket Mountain Plant on June 13-14, 2002. Several "test benches" were evaluated to further assist Graymont in determining reclamation success of seed mixes, growth amendments, seed bed preparation techniques, and experimental surficial amendments. Additionally, an annual evaluation of reference transects at the Cricket Mountain Plant was conducted.

BENCHES

Additional growing seasons have yielded more evidence as to which revegetation treatments are more successful within the first years of growth. It shall be important to continue to monitor these benches to determine which soil amendments are most effective in producing a healthy, self-sustaining vegetation community. Some benches may be nearing the possibility of bond release. Before the State of Utah is formally requested to visit Poison Mountain quarry for partial bond release, it may be warranted to assess each bench scheduled for bond release in a more thorough manner to produce a statistical mean and standard deviation for each bench. This can generally be produced by reading 3 randomly placed transects on each bench. In addition, photographs and field notes have been used since 1999 to augment information from the optical point projection device. Plant development is most notable on benches with irregular topography. Irregular surfaces create microsites that can promote plant establishment by protection from the wind and increased moisture accumulation. Although benches with smooth topography have lower vegetation cover, the species diversity on these benches is noteworthy.

REFERENCE TRANSECTS

An annual evaluation of the reference transects in native Juniper vegetation communities yielded vegetation cover estimates within the range of natural variation within Juniper vegetation communities. Significant differences can not be detected at this time due to the natural range of variation in these vegetation communities as well as a lack of data, but trends can be noted. It is common to find vegetation cover ranging between 15-45% within any given year in this type of vegetation community.

Appendix A – Bench treatments and seed mixes

Appendix A- Table 1 – Treatments of benches inspected in 2001

Bench	Seeding Date	Seed Mix Rate	Growth media	Surficial treatment	
5920 West	November, 1998 (first seeded in 1996)	22 PLS lbs broadcast	Limestone fines with growth media, growth media added in 1998 when reseeded	Limestone cobbles and uneven surface left	H
5900 West	November, 1998 (first seeded in 1996)	22 PLS lbs broadcast	Limestone fines with growth media, growth media added in 1998 when reseeded	Boulder Placement on bench –windbreak at end of bench, uneven surface left	M
5880 West	November, 1998	22 PLS lbs broadcast	6" growth media	Boulder placement on bench, uneven surface left	H
5900 West	November, 1998	22 PLS lbs broadcast	6-12" limestone fines with growth media	Primarily limestone fines, smooth surface	L
5920 NW	November, 1998	22 PLS lbs broadcast	6-12" limestone fines and composted manure	Limestone fines and cobbles	H
5880 Middle	November, 1998	22 PLS lbs broadcast	6-12" mixed limestone fines with growth media	Limestone cobbles, uneven surface left	H
5880 North	November, 1998	22 PLS lbs broadcast	6-12" limestone fines and composted manure	Limestone fines, smooth surface	M-L
5900 East	December, 1996	20 lbs/acre	Limestone fines	1500 lbs/ acre straw mulch, 50 lbs/acre 16-16-8 NPK fertilizer	L
5940 East	December, 1996	20 lbs/acre	Limestone fines	2500 lbs/acre straw mulch, 50 lbs/ acre 16-16-8 NPK fertilizer	L
5940 West	April, 1996	12 lbs/acre	Limestone fines	1000 lbs/acre hay, 40 lbs/acre 16-20-0- NPK fertilizer	L
5960 West	April, 1996	12 lbs/acre	Limestone fines	1000 lbs/acre straw, 40 lbs/acre 16-20-0- NPK fertilizer	L
5940 NW	April, 1996	12 lbs/acre	Topsoil over limestone fines	2000 lbs/acre hay, 40 lbs/acre 16-20-0 NPK fertilizer	H

Species
Bluebunch ★
Crested/★ Siberian
Streambank
Thickspike
Fourwing ★
Shadscale ★
Blacksage
RWR
IRG
IWG
Palmer
Koltai Prostrate
Gardner
Squirreltail
Didn't Work

Soil
1. Fines + Soil + Smooth
2. Fines + Manure + Smooth
3. Fines, mulch, fertilizer

1. Soil / Soil + ~~lime~~ fines, Fines + Manure + Rough
2. Rough, Boulders

Soils 1. ~~Lime~~ Fines + Soil
2. Soil
3. Fines + Manure
4. ~~Rock~~ Soil over fines

Surface 1. Cobbles, uneven
2. Boulders, uneven
3. Cobbles & fines
4. Hay & fertilizer

Appendix A - Table 2a. 1998 broadcast seed mix

Scientific Name	Common Name	Lbs/acre PLS
Agropyron cristatum	Nordan crested wheat	1
Agropyron fragile	Vavilov siberian wheatgrass	2
Oryzopsis hymenoides	Indian ricegrass	2-3
Agropyron dasystachyum	Thickspike wheatgrass	1
Agropyron riparium	Streambank wheatgrass	1
Elymus elymoides	Bottlebrush squirreltail	1-2
Penstemon eatonii	Firecracker penstemon	1/2
Sphaeralcea grossulariafolia	Globemallow	1/10 – ¼
Melilotus officinalis	Yellow sweetclover	1/10 – ¼
Kochia prostrata	Forage kochia	½ - 1
Ceratoides lanata	Winterfat	1 – 2
Atriplex canescens	Fourwing saltbush	1 –2
Atriplex gardneri	Gardner's saltbush	1 –2
Atriplex confertifolia	Shadscale	1 –2
Artemisia tridentata var nova	Black sagebrush	½

Appendix A -Table 2b. 1996 seed mix

Scientific Name	Common Name	Lbs/ acre PLS
Agropyron cristatum spp. desertorum	Crested wheatgrass	1.44
Elytrigia intermedia ssp trichoporum	Intermediate wheatgrass	2.88
Psathrostachys juncea	Russian wildrye	2.88
Kochia prostrata	Forage kochia	0.48
Melilotus officinalis	Yellow sweetclover	1.44
Atriplex confertifolia	Shadscale	1.44

Appendix A -Table 3. Summary of revegetated benches at the Cricket Mountain Plant, June, 2002.

Bench ID		5940E		5900E		5960W		5940W	
		Cover (%)	Rel	Cover(%)	Rel	Cover (%)	Rel	Cover (%)	Rel
Scientific Name	Common Name		Cover		Cover		Cover		Cover
tal Vegetation Cover		3		1		<1		4	
ck		6		15		2		1	
Gravel		61		80		98		95	
Bare soil				3					
Litter		28		1					
Cool season perennial grasses									
Agropyron fragile	Siberian wheatgrass								
Agropyron cristatum	Crested wheatgrass	<1				<1		<1	
Agropyron dasystachyum	Thickspike wheatgrass								
Agropyron intermedium	Intermediate wheatgrass	3	100%	<1				<1	
Agropyron riparium	Streambank wheatgrass								
Agropyron spicatum	Bluebunch wheatgrass	<1							
Elymus elymoides	Bottlebrush squirreltail								
Oryzopsis hymenoides	Indian ricegrass	<1		<1					
Psathyrostachys juncea	Russian wildrye	<1		<1		<1		<1	
Warm season perennial grasses									
Aristida purpurea	Purple three-awn	<1							
Introduced non-desirable annual grasses									
Bromus tectorum	Cheatgrass	<1							
Introduced non-desirable forbs									
Chorispora tenella	Blue mustard								
Halogeton glomeratus	Halogeton	<1		<1				<1	
Introduced desirable forbs									
Kochia prostrata	Forage kochia	<1		<1					
lilotus officinalis	Yellow sweetclover								
Native perennial forbs									
Penstemon eatonii	Eaton's penstemon								
Penstemon palmeri	Palmer's penstemon								
Sphaeralcea munroana	Munroe globemallow								
Native shrubs									
Artemisia nova	Black sagebrush	<1		<1					
Atriplex canescens	Four-wing saltbush	<1		1	100%	<1		3	75%
Atriplex confertifolia	Shadscale	<1		<1		<1		1	25%
Atriplex gardneri	Gardner's saltbush								
Gutierrezia sarothrae	Broom snakeweed	<1							

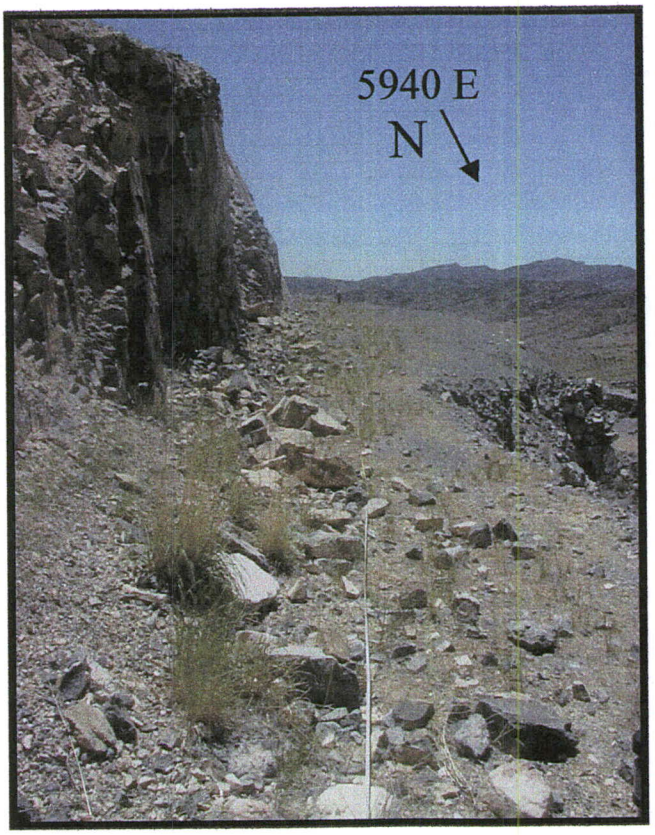
Appendix A -Table 3. Summary of revegetated benches at the Cricket Mountain Plant, June, 2002.

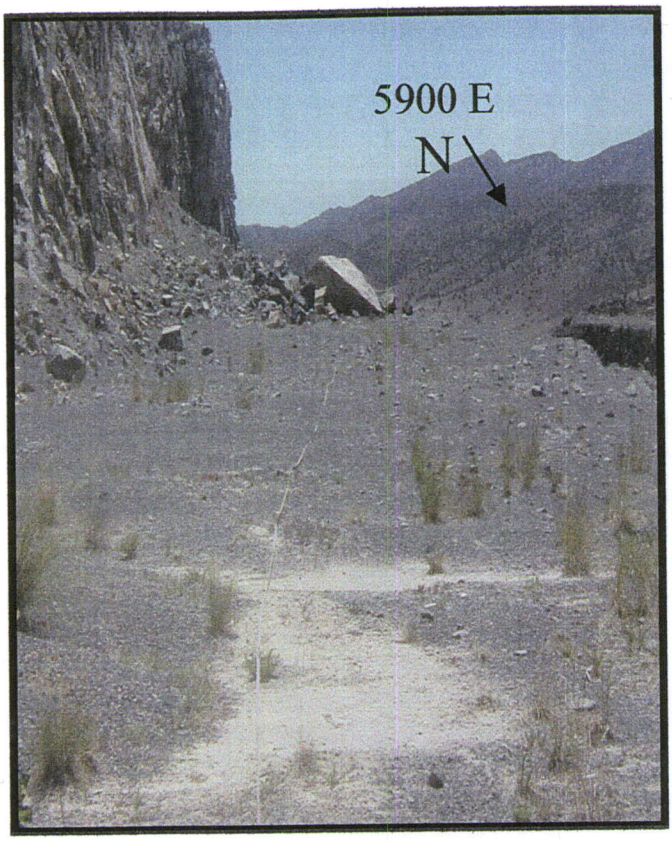
Bench ID		5920W		5900W		5888W		5880N	
		Cover (%)	Rel	Cover (%)	Rel	Cover (%)	Rel	Cover (%)	Rel
Scientific Name	Common Name		Cover		Cover		Cover		Cover
l Vegetation Cover		**16**		**9**		**21**		**8**	
.k		14		14		18		1	
Gravel		63		64		47		90	
Bare soil		2		2		4			
Litter		5		12		10			
Cool season perennial grasses									
Agropyron fragile	Siberian wheatgrass	5	31%	2	22%	5	24%		
Agropyron cristatum	Crested wheatgrass	5	31%	3	33%	15	71%	2	25%
Agropyron dasystachyum	Thickspike wheatgrass	1	6%	<1		<1			
Agropyron intermedium	Intermediate wheatgrass	<1		<1					
Agropyron riparium	Streambank wheatgrass	3	19%	<1		1	5%		
Agropyron spicatum	Bluebunch wheatgrass								
Elymus elymoides	Bottlebrush squirreltail								
Oryzopsis hymenoides	Indian ricegrass	<1		2	22%	<1		<1	
Psathyrostachys juncea	Russian wildrye	<1							
Warm season perennial grasses									
Aristida purpurea	Purple three-awn								
Introduced non-desirable annual grasses									
Bromus tectorum	Cheatgrass	<1		<1				<1	
Introduced non-desirable forbs									
Chorispora tenella	Blue mustard					<1			
Halogeton glomeratus	Halogeton							1	13%
Introduced desirable forbs									
Kochia prostrata	Forage kochia	<1		<1		<1		<1	
lotus officinalis	Yellow sweetclover	<1							
Native perennial forbs									
Penstemon eatonii	Eaton's penstemon	2	13%	1	11%	<1		<1	
Penstemon palmeri	Palmer's penstemon					<1			
Sphaeralcea munroana	Munroe globemallow	<1		<1		<1		<1	
Native shrubs									
Artemisia nova	Black sagebrush	<1				<1		<1	
Atriplex canescens	Four-wing saltbush	<1		1	11%	<1		4	50%
Atriplex confertifolia	Shadscale	<1						<1	
Atriplex gardneri	Gardner's saltbush							1	12%
Gutierrezia sarothrae	Broom snakeweed								

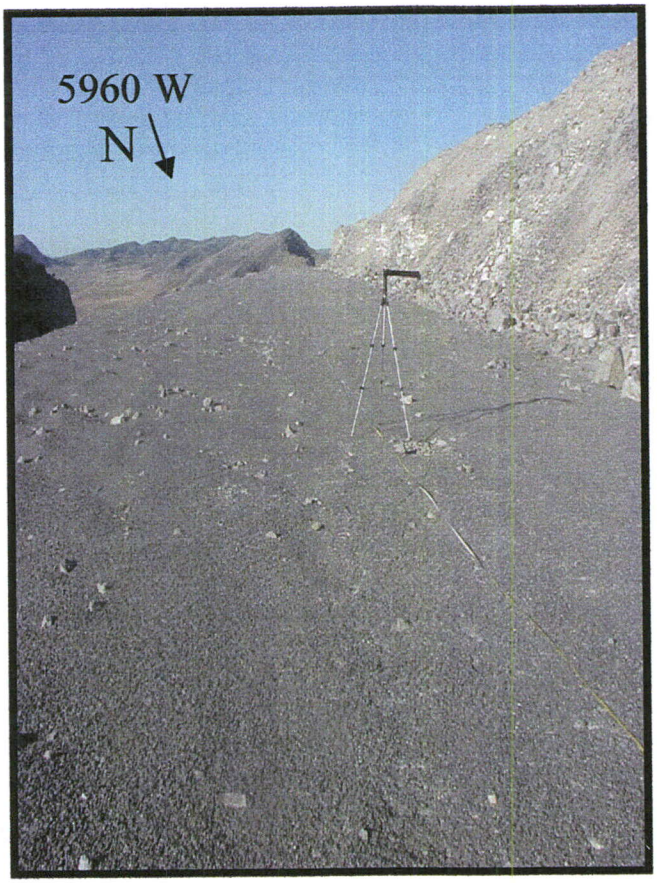
Appendix A -Table 3. Summary of revegetated benches at the Cricket Mountain Plant, June, 2002.

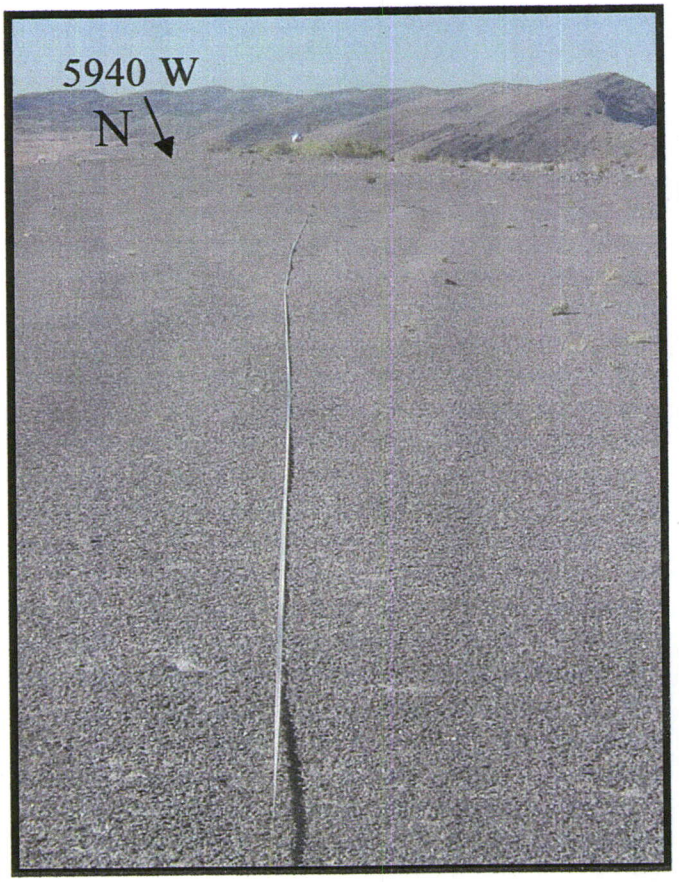
Bench ID		5940NW		5920NW		5900		5880 middle	
		Cover (%)	Rel	Cover (%)	Rel	Cover (%)	Rel	Cover (%)	Rel
Scientific Name	Common Name		Cover		Cover		Cover		Cover
al Vegetation Cover		18		10		10		16	
ck		13				7		11	
Gravel		55		89		79		68	
Bare soil									
Litter		14		1		2		5	
Cool season perennial grasses									
Agropyron fragile	Siberian wheatgrass			3	30%	6	60%	3	19%
Agropyron cristatum	Crested wheatgrass	<1		2	20%	<1		10	63%
Agropyron dasystachyum	Thickspike wheatgrass							<1	
Agropyron intermedium	Intermediate wheatgrass	8	44%						
Agropyron riparium	Streambank wheatgrass			<1				2	13%
Agropyron spicatum	Bluebunch wheatgrass								
Elymus elymoides	Bottlebrush squirreltail	<1						1	7%
Oryzopsis hymenoides	Indian ricegrass							<1	
Psathyrostachys juncea	Russian wildrye	4	22%						
Warm season perennial grasses									
Aristida purpurea	Purple three-awn								
Introduced non-desirable annual grasses									
Bromus tectorum	Cheatgrass	3	17%	<1		<1			
Introduced non-desirable forbs									
Chorispora tenella	Blue mustard								
Halogeton glomeratus	Halogeton	<1		<1		2	20%		
Introduced desirable forbs									
Kochia prostrata	Forage kochia	1	6%	<1		<1		<1	
ilotus officinalis	Yellow sweetclover	1	6%			1	10%	<1	
Native perennial forbs									
Penstemon eatonii	Eaton's penstemon			<1		<1		<1	
Penstemon palmeri	Palmer's penstemon							<1	
Sphaeralcea munroana	Munroe globemallow							<1	
Native shrubs									
Artemisia nova	Black sagebrush			<1		<1		<1	
Atriplex canescens	Four-wing saltbush	1	6%	5	50%	1	10%	<1	
Atriplex confertifolia	Shadscale	<1		<1		<1		<1	
Atriplex gardneri	Gardner's saltbush			<1		<1			
Gutierrezia sarothrae	Broom snakeweed							<1	

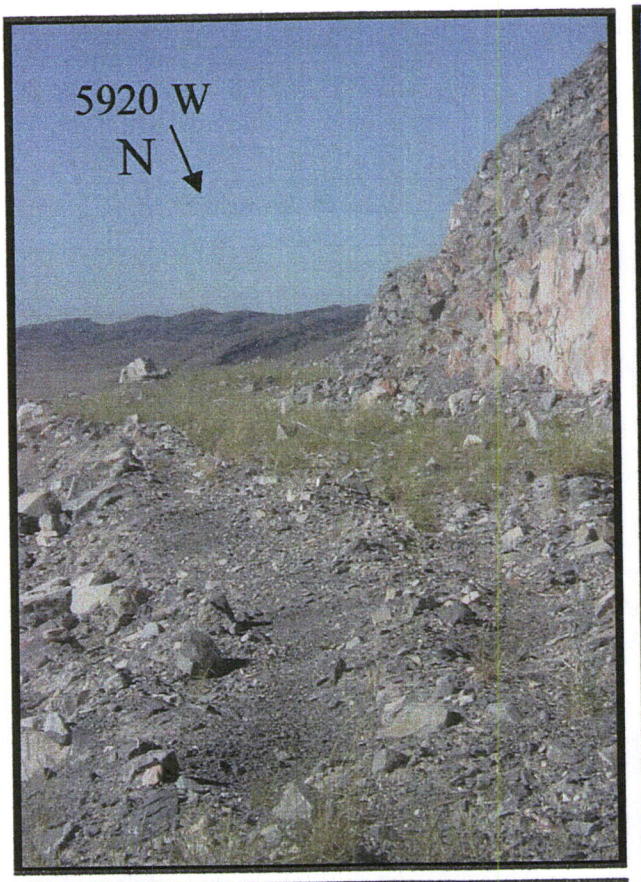
APPENDIX B
Photos of treated benches

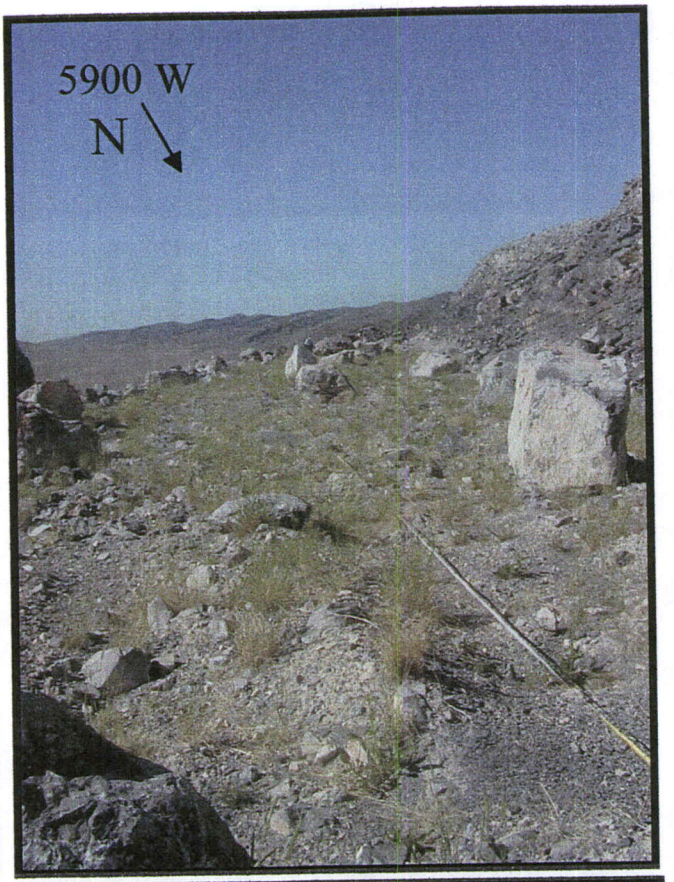

5940 E
N

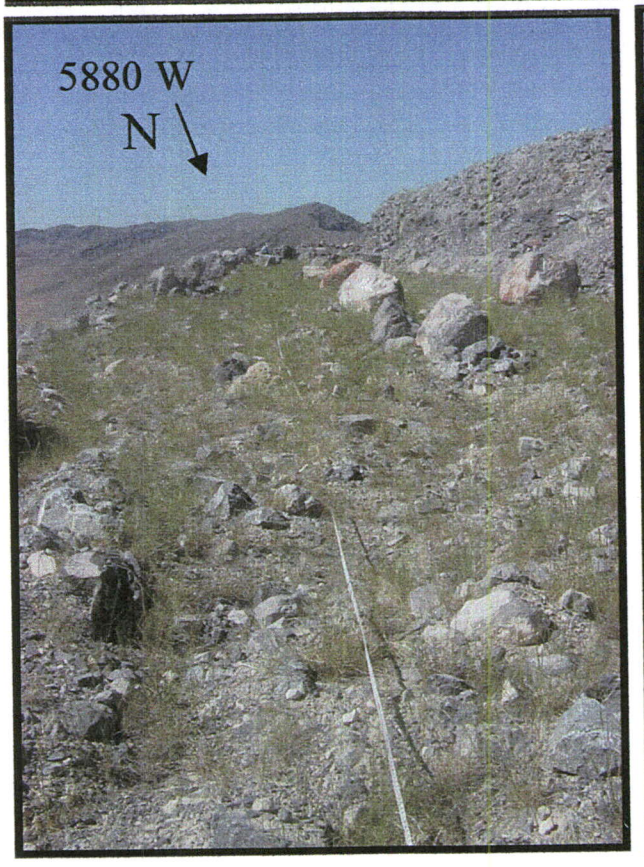

5900 E
N


5960 W
N

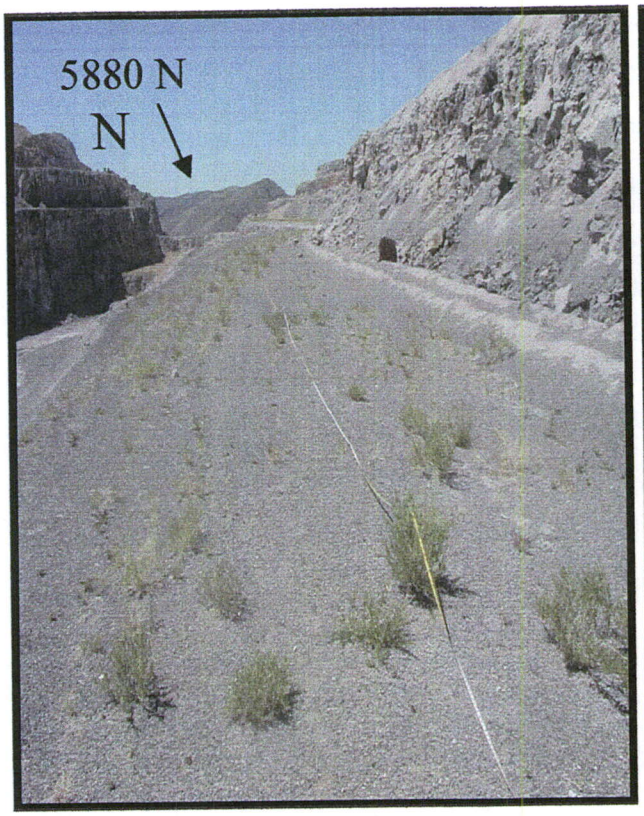

5940 W
N

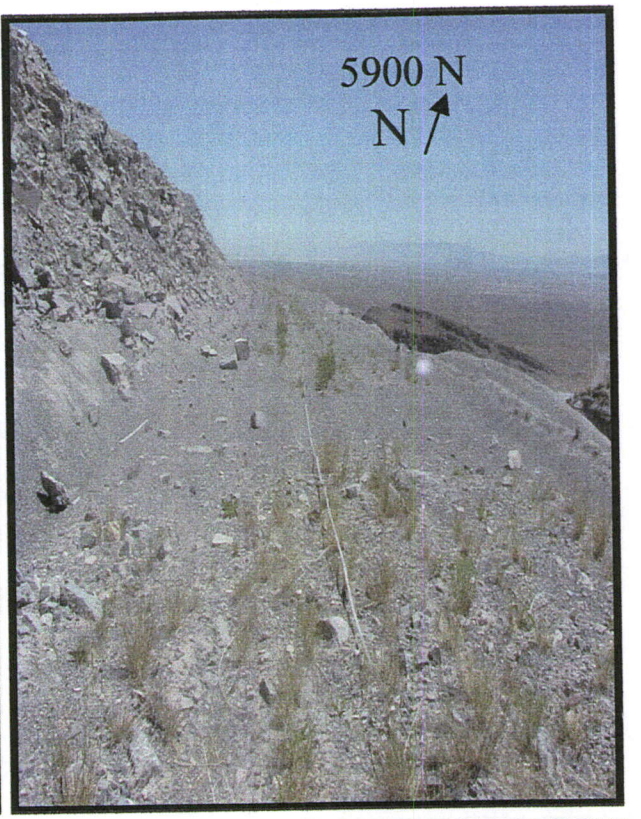

5920 W
N

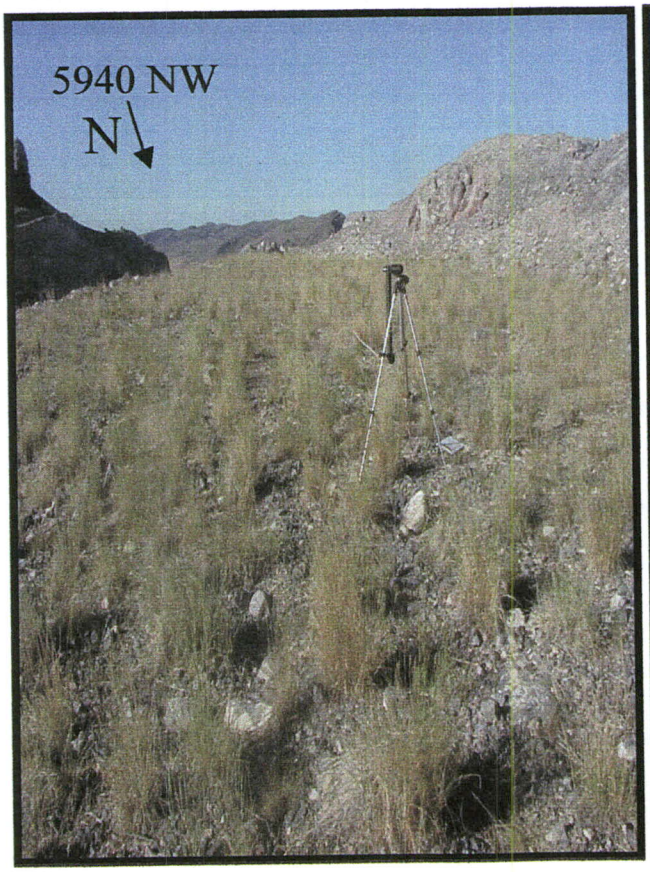

5900 W
N

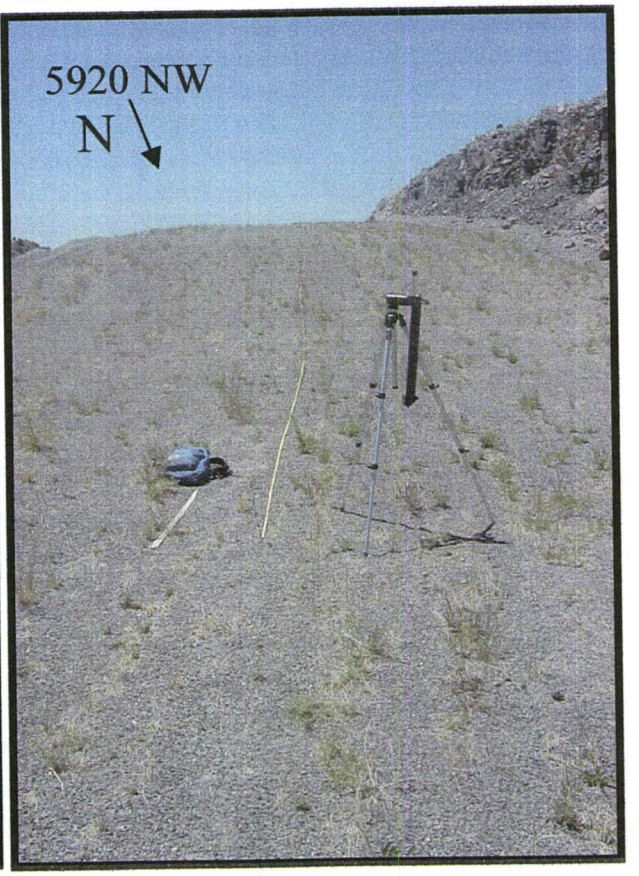

5880 W
N


5880 mid
N


5880 N
N


5900 N
N

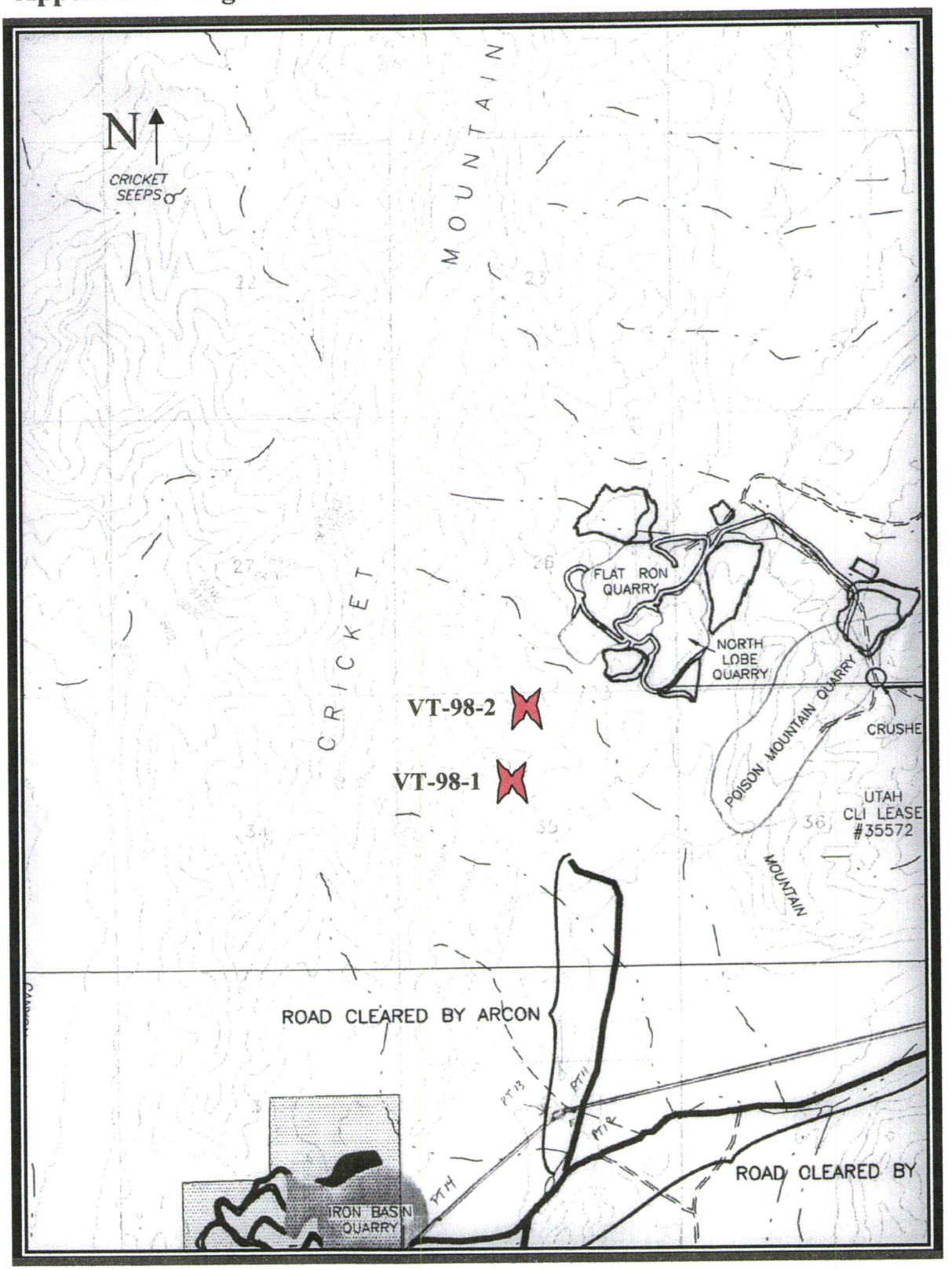

5940 NW
N


5920 NW
N

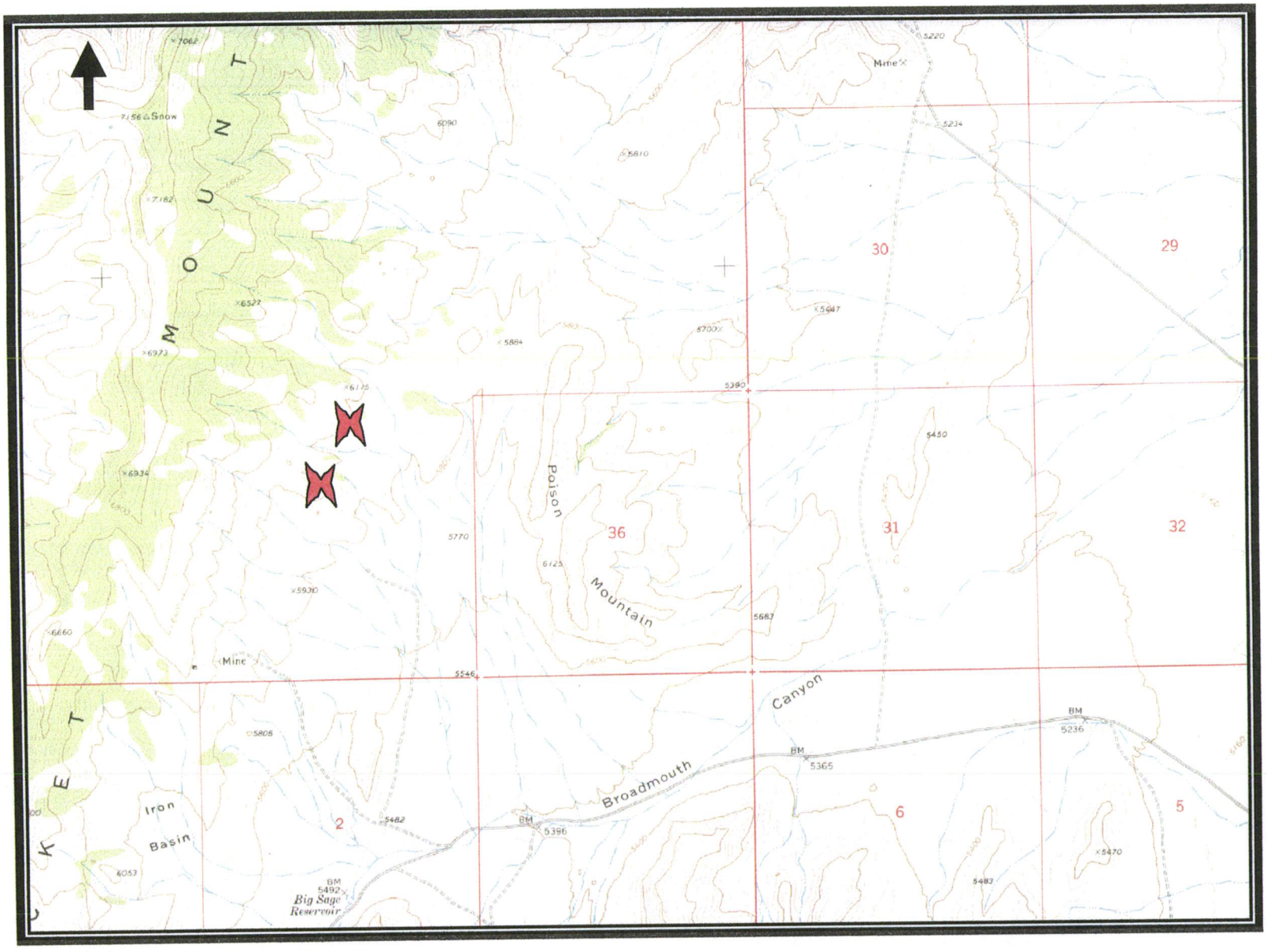
Transition between 5880 mid to 5880 N

Appendix C
Reference Transects

Appendix C – Figure 1: Reference sites in relation to mining operations.



Appendix C -Figure 2: Reference sites on USGS 7.5 min. 'Candland Spring Quadrangle'.



Appendix C- Table 1-Reference Transect 1- Cricket Mountain Plant- June, 2002

ScientificName	Common name	Mean	St Dev	St Error	Low	High	Rel Cover	Freq
Cool season perennial grasses								
Agropyron spicatum	Bluebunch wheatgrass	8.667	2.309	1.333	6.0	10.0	37.20	100.00
Oryzopsis hymenoides	Indian ricegrass	1.333	0.577	0.333	1.0	2.0	5.70	100.00
Poa sandbergii	Sandberg's bluegrass	0.000	0.000	0.000	0.0	0.0	0.00	33.33
Stipa comata	Needle and thread	0.000	0.000	0.000	0.0	0.0	0.00	33.33
Sub-total		**10.000**					**42.90**	
Warm season perennial grasses								
Aristida purpurea	Purple threeawn	0.000	0.000	0.000	0.0	0.0	0.00	100.00
Hilaria jamesii	Galleta grass	0.000	0.000	0.000	0.0	0.0	0.00	66.67
Sub-total		**0.000**					**0.00**	
Annual grasses								
Bromus rubens	Red brome	0.000	0.000	0.000	0.0	0.0	0.00	100.00
Perennial forbs								
Haplopappus acaulis	Stemless goldenweed	0.000	0.000	0.000	0.0	0.0	0.00	66.67
Lomatium grayii	Gray's lomatium	0.333	0.577	0.333	0.0	1.0	1.40	100.00
Sphaeralcea munroana	Munroe's globemallow	0.000	0.000	0.000	0.0	0.0	0.00	33.33
Sub-total		**0.333**					**1.40**	
Annual and biennial forbs								
Chorispora tenella	Purple mustard	0.000	0	0	0.0	0.0	0.00	66.67
Sub-shrubs								
Gutierrezia sarothrae	Broom snakeweed	2.333	1.528	0.882	1.0	4.0	10.00	100.00
Petrophytum caespitosum	Rock spirea	0.667	1.155	0.667	0.0	2.0	2.80	66.67
Sub-total		**3.000**					**12.80**	

Appendix C- Table 1-Reference Transect 1- Cricket Mountain Plant- June, 2002

ScientificName	Common name	Mean	St Dev	St Error	Low	High	Rel Cover	Freq
Shrubs								
Artemisia nova	Black sagebrush	4.000	1.000	0.577	3.0	5.0	17.17	100.00
Atriplex confertifolia	Shadscale	0.000	0.000	0.000	0.0	0.0	0.00	100.00
Ephedra nevadensis	Nevada ephedra	0.000	0.000	0.000	0.0	0.0	0.00	100.00
Haplopappus watsonii	Goldenbush	0.333	0.577	0.333	0.0	1.0	1.40	100.00
Purshia mexicana	Cliffrose	3.000	2.646	1.528	1.0	6.0	12.87	100.00
Tetradymia spinescens	Spiny horsebrush	0.000	0.000	0.000	0.0	0.0	0.00	33.33
Sub-total		**7.333**					**31.44**	
Trees								
Juniperus osteosperma	Utah juniper	2.667	2.517	1.453	0.0	5.0	11.40	100.00
Total Vegetation Cover		23.333	3.512	2.028	20.0	27.0		
Litter		12.667	1.528	0.882	11.0	14.0		
Rock		24.667	5.508	3.180	19.0	30.0		
Gravel		34.330	3.055	1.764	31.0	37.0		
Bare Soil		5.000	1.732	1.000	3.0	6.0		
Total Ground Cover		95.000	1.732	1.000	94.0	97.0		

Appendix C-Table 2-Reference Transect 2- Cricket Mountain Plant June, 2002

ScientificName	Common Name	Mean	St Dev	St Error	Low	High	Rel. Cover	Freq
Cool season perennial grasses								
Agropyron spicatum	Bluebunch wheatgrass	12.000	4.359	2.517	9.0	17.0	45.60	100.00
Oryzopsis hymenoides	Indian ricegrass	0.333	0.577	0.333	0.0	1.0	1.25	66.67
Poa sandbergii	Sandberg's bluegrass	0.333	0.577	0.333	0.0	1.0	1.25	66.67
Stipa comata	Needle and thread	0.333	0.577	0.333	0.0	1.0	1.25	66.67
Sub-total		**12.999**					**49.35**	
Warm season perennial grasses								
Aristida purpurea	Purple threeawn	1.333	1.528	0.882	0.0	3.0	5.00	66.67
Hilaria jamesii	Galleta grass	0.000	0	0	0.0		0.00	66.67
Sub-total		**1.333**					**5.00**	
Annual grasses								
Bromus rubens	Red brome	0.000	0.000	0.000	0.0	0.0	0.00	100.00
Perennial forbs								
Lomatium grayii	Gray's lomatium	0.333	0.577	0.333	0.0	1.0	1.25	100.00
Sphaeralcea munroa	Munroe's globemallow	0.000	0.000	0.000	0.0	0.0	0.00	100.00
Sub-total		**0.333**					**1.25**	
Sub-shrubs								
Gutierrezia sarothrae	Broom snakeweed	2.667	2.082	1.202	1.0	5.0	10.10	100.00
Petrophytum caespitosum	Rock spirea	0.333	0.577	0.333	0.0	1.0	1.25	33.33
Sub-total		**3.000**					**11.35**	

Appendix C-Table 2-Reference Transect 2- Cricket Mountain Plant June, ∠002

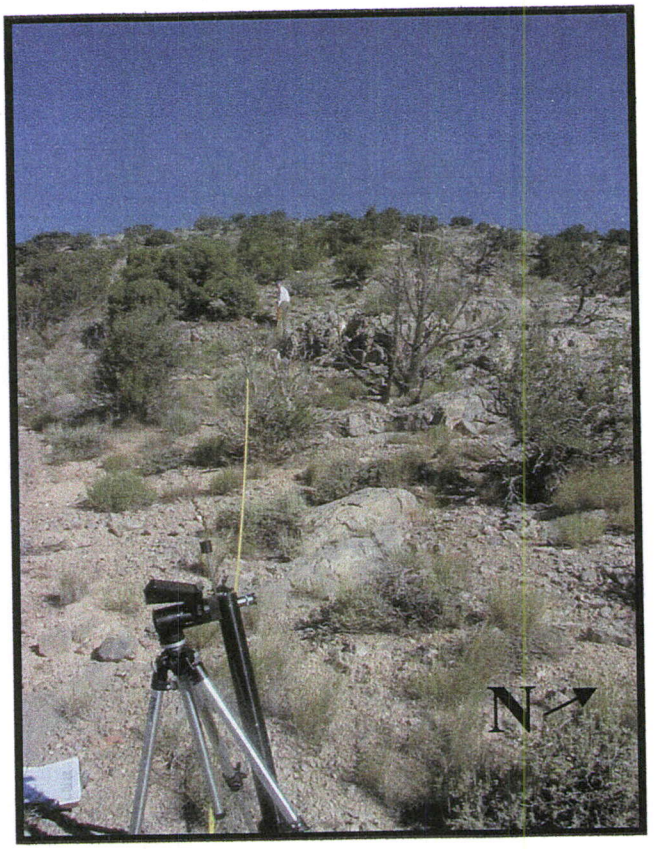
ScientificName	Common Name	Mean	St Dev	St Error	Low	High	Rel. Cover	Freq
Shrubs								
Artemisia nova	Black sagebrush	3.000	1.000	0.577	2.0	4.0	11.40	100.00
Atriplex confertifolia	Shadscale	0.000	0.000	0.000	0.0	0.0	0.00	66.67
Ephedra nevadensis	Nevada ephedra	0.000	0.000	0.000	0.0	0.0	0.00	66.67
Haplopappus watsonii	Goldenweed	0.333	0.577	0.333	0.0	1.0	1.25	100.00
Purshia mexicana	Cliffrose	3.333	1.528	0.882	2.0	5.0	12.60	100.00
Sub-total		**6.666**					**25.25**	
Cacti and succulents								
Echinocereus triglochidiatus	Claret cup cactus	0.000	0.000	0.000	0.0	0.0	0.00	66.67
Opuntia polyacantha	Prickly pear cactus	0.000	0.000	0.000	0.0	0.0	0.00	66.67
Trees								
Juniperus osteosperma	Utah juniper	2.333	1.528	0.882	1.0	4.0	8.30	100.00
Total Vegetation Cover		26.333	2.082	1.202	24.0	28.0		
Litter		8.667	1.528	0.882	7.0	10.0		
Rock		33.330	11.547	6.667	20.0	40.0		
Gravel		22.000	7.211	4.163	16.0	30.0		
Bare Soil		9.667	5.774	3.333	3.0	13.0		
Total Ground Cover		90.333	5.773	3.333	87.0	97.0		

Appendix C -Table 3. Comparison of Reference Transects -1998, 1999, 2000, 2001, and 2002

		TRANSECT 1				
		1998	1999	2000	2001	2002
Total Vegetation Cover (%)		38.33	32.67	22.67	19.67	23.30
Litter (%)		11.67	15.00	17.70	10.00	12.67
Gravel (%)		6.00	22.00	22.00	34.30	34.30
Rock (%)		36.67	26.67	34.00	28.67	24.67
Bare Soil (%)		7.33	3.33	3.70	7.33	5.00
Total Cover (%)		92.33	96.67	96.30	92.67	95.00
Cool season perennial grasses						
Agropyron spicatum	Bluebunch wheatgrass	7.70	11.00	9.30	5.67	8.67
Blepharidacne kingii	King's desert grass		<1	<1	<1	<1
Oryzopsis hymenoides	Indian ricegrass	<1	<1	0.3	0.3	1.33
Poa sandbergii	Sandberg's bluegrass	0.30	0.33	<1	0.33	<1
Stipa comata	Needle and thread	<1	0.33	<1	0.33	<1
Sub-total		8.00	11.67	9.60	7.33	10.00
Warm season perennial grasses						
Aristida purpurea	Three awn			2	0.33	<1
Hilaria jamesii	Galleta grass	<1		0.3	0.33	<1
Sub-total				2.3	0.66	
Annual grasses						
Bromus rubens	Red brome	<1	<1	<1	0.33	<1
Bromus tectorum	Cheatgrass	8.00	3.33	0.30	<1	<1
Sub-total		8.00	3.33	0.30	0.33	
Perennial forbs						
Haplopappus acaulis	Stemless goldenweed	<1	0.33	<1	<1	<1
Lomatium grayii	Gray's lomatium	0.33	<1	<1	<1	0.33
Phlox austromontana	Desert phlox	<1	<1	<1	<1	0.00
Sphaeralcea munroa	Munroe's globemallow	<1	<1	<1	<1	<1
Sub-total		0.33	0.33	<1	0.33	0.33
Sub-shrubs						
Gutierrezia sarothrae	Broom snakeweed	4.30	2.00	0.70	3.00	2.33
Petrophytum caespitosum	Rock spirea	<1	<1	<1	0.33	0.67
Sub-total		4.30	2.00	0.70	3.33	3.00
Shrubs						
Artemisia nova	Black sagebrush	5.67	7.67	2.70	3.00	4.00
Atriplex confertifolia	Shadscale		<1	<1	<1	<1
Ephedra nevadensis	Nevada ephedra	1.00	0.67	<1	<1	<1
Haplopappus watsonii	Goldenbush		<1	<1	1.33	0.33
Purshia mexicana	Cliffrose	5.00	3.67	4.30	3.00	3.00
Tetradymia spinescens	Spiny horsebrush					<1
Sub-total		11.67	12.00	7.00	7.33	7.33
Cacti and succulents						
Echinocereus triglochidiatus	Claret cup	<1	0.33	<1	<1	0.00
Opuntia polyacantha		<1			<1	0
Sub-total			0.33	<1	<1	0
Trees						
Juniperus osteosperma	Utah Juniper	7.00	3.00	2.7	1	2.667
Sub-total		7.00	3.00	2.7	1	2.7

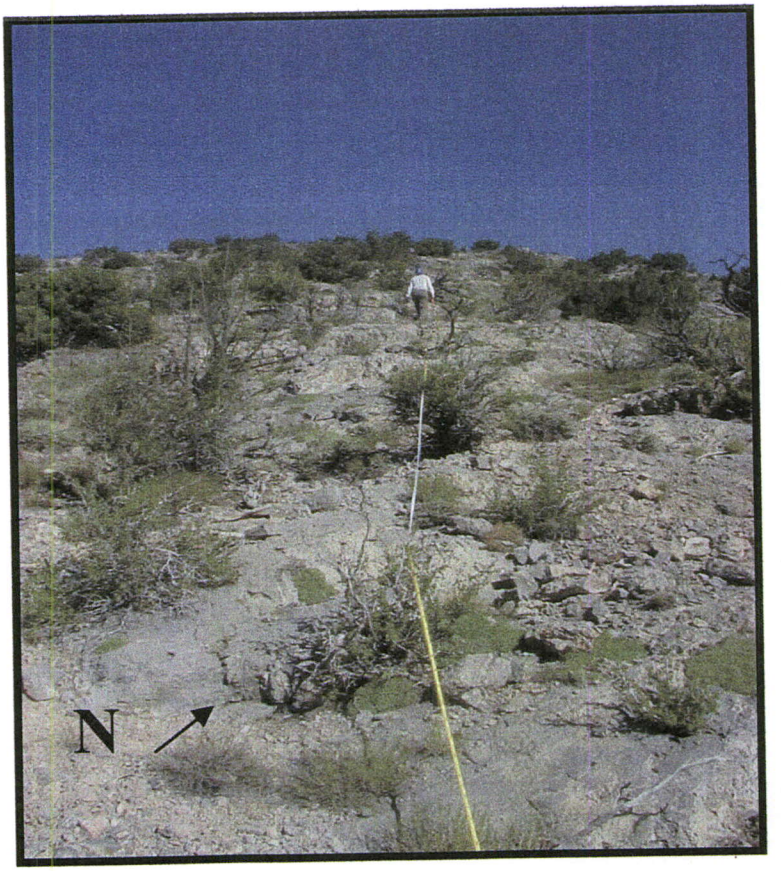
Appendix C -Table 3. Comparison of Reference Transects -1998, 1999, 2000, 2001, and 2002

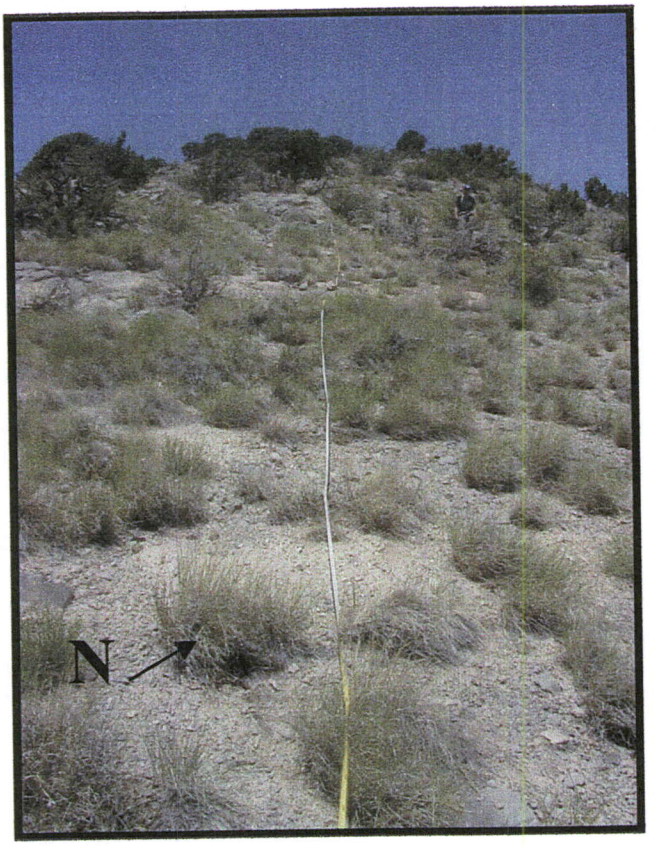
		TRANSECT 2				
		1998	1999	2000	2001	2002
Total Vegetation Cover (%)		30.00	26.00	22.30	23.33	26.30
Litter (%)		8.67	13.30	15.70	17.00	8.67
Gravel (%)		14.30	31.00	25.70	24.33	22.00
Rock (%)		38.33	24.70	33.30	27.33	33.33
Bare Soil (%)		8.67	5.00	3.00	8.00	9.67
Total Cover (%)		91.30	95.00	97.00	92.00	90.33
Cool season perennial grasses						
Agropyron spicatum	Bluebunch wheatgrass	13.70	9.30	9.00	9.33	12.00
Blepharidacne kingii	King's desert grass	<1	1.00	<1	<1	0.00
Oryzopsis hymenoides	Indian ricegrass	<1	0.30	<1	<1	0.33
Poa sandbergii	Sandberg's bluegrass	<1	0.30	<1	<1	0.33
Stipa comata	Needle and thread	1.00	1.00	0.3	0.67	0.33
Sub-total		14.70	11.90	9.30	10.67	12.99
Warm season perennial grasses						
Aristida purpurea	Three awn	0.30		1.3	0.67	1.33
Hilaria jamesii	Galleta grass	0.30	<1	<1	<1	<1
Sub-total		0.60		1.3	0.67	1.33
Annual grasses						
Bromus rubens	Red brome	<1	<1	0.3	<1	<1
Bromus tectorum	Cheatgrass	4.00	3.70	1.00	1.67	<1
Sub-total		4.00	3.70	1.30	1.67	
Perennial forbs						
Haplopappus acaulis	Stemless goldenweed	<1	<1	<1	<1	0
Lomatium grayii	Gray's lomatium	0.33	<1	0.67	<1	0.33
Phlox austromontana	Desert phlox	<1	<1	<1	<1	0
Sphaeralcea munroa	Munroe's globemallow	0.33	<1	<1	<1	<1
Sub-total		0.67	<1	0.67	0.67	0.33
Sub-shrubs						
Gutierrezia sarothrae	Broom snakeweed	3.00	5.70	2.33	3.00	2.67
Petrophytum caespitosum	Rock spirea	<1	<1	<1	0.67	0.33
Sub-total		3.00	5.70	2.33	3.67	3.00
Shrubs						
Artemisia nova	Black sagebrush	2.30	1.30	3.67	2.67	3.00
Atriplex confertifolia	Shadscale		<1		<1	<1
Ephedra nevadensis	Nevada ephedra		<1		<1	<1
Haplopappus watsonii	Goldenbush	<1	3.30		<1	0.33
Purshia mexicana	Cliffrose	2.67	<1	3.00	2.67	3.33
Tetradymia spinescens	Spiny horsebrush				0.00	0
Sub-total		5.00	4.60	6.67	5.33	6.66
Cacti and succulents						
Echinocereus triglochidiatus	Claret cup	<1	<1	<1	<1	<1
Opuntia polyacantha					<1	<1
Sub-total			<1		<1	
Trees						
Juniperus osteosperma	Utah Juniper	1.70	<1	0.67	2	2.33
Sub-total		1.70	<1	0.67	2	2.33



Reference Transect 1

Azimuth 300°





Reference Transect 2

Azimuth - 302°